Reference is also had to copending, commonly-owned U.S. patent application Ser. No. 09/815,164, filed on March 22, 2001, entitled "Prioritized-Routing for an Ad-Hoc, Peer-to-Peer, Mobile Radio Access System", which is incorporated by reference herein, in which there is disclosed an example of routing table messaging which may be used in the present invention.

## SUMMARY OF THE INVENTION

It is the primary objective of the present invention to provide an ad-hoc radio system as part of an overall, larger cellular network, and/or as a stand-alone, independent system, in order to provide commercial use for providing voice, data and video communications between radio terminals of the radio system of the invention and between equipment outside the system of the invention.

It is also a primary objective of the present invention to provide an overall protocol for ad-hoc radio system not utilizing a fixed base station, whereby a connection path by which a call is made takes into consideration the power loss associated therewith, in order to determine the least-energy routing of a call for the particular service type being transmitted, such as voice, data or video.

The protocol of the present invention is based on a time-division duplex (TDD) plus code-division multiple access (CDMA) burst packet technology used within the channel access algorithm of the system of the present invention. This provides the improvements in throughput and reliability that are required to deliver high quality voice, video and data. The reservation channel implements a time division multiple access algorithm with dynamic slot allocation. In a distributed manner, nodes determine geographic reuse of slots based on channel quality. Signal quality calculations are used to determine the likelihood of a slot reuse causing destructive interference within a node's neighborhood. Requests for slot usage are compared with the known

traffic pattern and accepted or rejected by nodes within RF signal range based on the signal quality calculations. Additionally, the algorithm of the present invention readily provides for the mobility of nodes between geographic areas through the use of a special slot that is reserved for nodes without reservations. Nomadic nodes use this slot to locate a permanent slot to claim for their use. Once claimed, the collision free properties can be enforced to improve, the reliability and throughput of messages generated by this node. This results in a maximal use of the spectrum within a geographic area.

The system of the present invention utilizes a method and algorithm which, in the preferred embodiment, is intended for an ad-hoc network system called "ArachNet", and is based on least-energy routing of calls from between network radio terminals. In simple terms, the major component of the routing decision is to choose I route to the destination that uses the least amount of energy over the complete route. The major reason for this is that least-energy routing minimizes the radiated RF energy, in order to reduce interference between terminal A consequence of this is that it creates the most efficient use of the power supply of the terminals. Routing tables based on this least energy routing a developed by the system of the invention, and stored at one or more radio terminals, which routing tables are transmitted and stored by other terminals forming part of the link by which a call is connected. An example of such a routing table is disclosed in copending, commonly-owned U.S. patent application Ser. No. 09/815,164, filed on March 22, 2001, entitled "Prioritized-Routing for an Ad-Hoc, Peer-to-Peer, Mobile Radio Access System", which is incorporated by reference herein. Variants or equivalents of the system of the invention are possible. There are a number of variants of this approach that would provide acceptable performance. These variants include tuning of each of the four access schemes--CSMA/CA, TDMA, FDMA, and CDMA.' For example, the width of the time slots may be adjusted based on the specific network over which the protocol is executing. Performance of the network is very dependent on the number of parallel data channels which can be used. A balance exists between the capacity of the

service group (SG) will adjust its power in the configuration channel (CC), even if only one route has a real need for it, as described hereinbelow.

The use of high transmit-power has two side effects. It drains the battery of mobile AT's faster, and reduces the availability of system resources, making it difficult to reuse frequency and time slots. If the connection path between the gateway 22 and the client AT has $N_1$ hops, and the gateway power is $P_1$, and the length of the connection route should be no more than $N_2$ hops, the new power to be used at each end of the path is $P_2$.

$$P_2 = P_1 + \left[ 30\lambda \log_{10}\left(\frac{N_1}{N_2}\right)\right] dBm \qquad (0\text{-}1)$$

Equation (0-1) provides a means to compute the new, greater power $P_2$ that should make the path to have only $N_2$ hops. The parameter $\lambda$ is the "space absorption" factor. Its value is dependent on many factors, including the propagation media characteristics, such as free space, concrete walls and floors, wooden walls, metal frame structure, foliage, and the like, lateral reflections, vertical reflections, etc. The initial value for $\lambda$ may be 1.0, but it should be adjusted based on system reaction to the intent to the changing of the number of hops.

The corrected power is applied at the gateway and at the client AT, a fact that attracts automatic change of the power profile along the entire connection route. If the correction does not have the expected result, a second correction will be applied after the route has been established.

"Messaging Based on Least Energy Routing"

The protocol of the present invention is based on least energy routing determination, as discussed previously especially when transmitting data. The routing table messaging that is exchanged between terminals may have a format as that disclosed in copending, commonly-owned U.S. patent application Ser. No. 09/815,164, filed on March 22, 2001, entitled "Prioritized-Routing for an Ad-Hoc, Peer-to-Peer, Mobile Radio Access System", which is incorporated by reference herein.

The minimum energy routing of the protocol of the invention is used to set up the optimal path of a call. The following algorithm of the protocol of the present invention is based on this minimum energy routing.

source-routing (message_ptr,msg-length,destination, msg-type)

/~ source based routing including link adaption algorithm

*/

opt_route(destination, msg_type)

/* determine optimal routeto destination this will return the best available route

based on Class Of Service (COS) from msg_type and other network parameters

including link quality. The returned information will be used to calculate the data rate and power level

*/

calc_symbol_rate (sym_rate)

calc_code_rate (code_rate)

calc_pwr_level (pwr_level)

send_msg(RTS,msg_length,destination,symjate,code_rate,pwr_level)'

/* send RTS to first router and await CTS to send the data packet

opt_route (destination, msg type)

RTS refers to Request-To-Send message; CTS refers to Clear-To-Send message; msg refers to the message sent from each terminal.